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EDITORIAL

Economy must still be the watchword in the use of lubricating oils as well as of other petroleum products. Motorless Sundays have effectively brought home to some readers of *Lubrication* the shortage of petroleum stocks due to abnormal war conditions. Economy in the use of lubricants will also assist in building up reserve stocks and will at the same time ease up on the gasoline and fuel oil situation. At the present writing reserve stocks of petroleum are being drawn upon at a rate greater than two million barrels or nearly one hundred million gallons per month.

The following paragraph is quoted from a recent letter of Mr. John T. Holland, a former employee of this office, who is now located at 30th Training Battery, F. A. C. O. T. S., Camp Taylor, Kentucky:

"Beginning at 5.15 A. M. there is not a minute of the day that is not provided for by schedule until 9 P. M., and then there is just fifteen minutes left to retiring time. It is a very busy period, you may be sure, yet not too busy to think of the times when every day was comparatively a holiday. Many a time and oft do I think of that wonderful office in the Whitehall Building. Especially is this true when we go out for our class in gun laying, as a barrel of Texaco Oil is sure to meet your vision when you enter a gun shed. Texaco is not doing its bit, but apparently the greater part in lubricating the implements of war."

YOUR CHANCE TO HAMMER THE HUN.

The only way to win a fight is to hammer the enemy until he quits. That's the way the United States is going about the war, but there is no sense in attempting to disguise the fact that the enemy will stand a lot of hammering. It is necessary for us to provide a gigantic hammer. Therefore we are extending the age limits for military service so as to provide for an army of 5,000,000, and now the government is asking us to absorb the Fourth Liberty Loan, far bigger than any of the others.

We can do it. We must do it, for if we should not there would be such rejoicing in Germany over America's

inability to finance her programme as would be humiliating and positively dangerous for us. Their troops would be heartened and ours discouraged by the thought that America was not enthusiastically in the war, determined to win at any cost.

So we must prepare to buy Liberty Bonds of the fourth issue with every dollar we can rake and scrape together. If we do that, we shall back up the soldiers at the front as they need to be backed up and we shall serve notice on the Central Powers that they will have to quit, no matter how hard they may fight.

LUBRICATING A LARGE STEEL PLANT

HAVE you ever stopped to think that not a single one of the ships, aeroplanes, tanks, motor cars, guns or shells for Uncle Sam's Fighting Forces could be produced if it were not for the little drops of oil which lubricate the vast machinery used for their manufacture? We have all read about the marvelous feats of shipbuilding and the enormous steel plants and rolling mills which are making the plates for the hulls, but except for those who are directly identified with the mills themselves there are very few people who have heard about the lubricants that keep the bearings and the gears of these massive machines moving or the manner in which these lubricants are used. How important correct lubrication is and how costly inefficient lubrication can be, only the operators and the mechanical men of the steel industry know, and because they know they insist upon the best there is, applied in the right way.

From the time the ore is mined up to its final consumption for industrial uses the materials are handled by machinery. In the great Mesabi Ranges of the Great Lakes the ore is dug out of the ground by enormous steam shovels which load the ore into railroad cars for transportation to the docks. Steamers holding thousands of tons carry the ore down the Great Lakes to the railroad terminals where it is unloaded by automatic machinery, transferred to storage bins and finally dumped by gravity into railway cars. These cars are hauled to the blast furnaces where the ore is unloaded, sometimes by running the cars upon high trestles, and allowing the ore to fall by gravity into the storage bins. At other places big cradles raise the car and turn it completely upside down, emptying its contents on to an ore pile alongside the track. In this way an entire car can be unloaded in two or three minutes. Traveling ore bridges distribute the ore into the various bins from which it is taken as needed for the furnaces.

A blast furnace consists essentially of a stack provided at the top with an opening to receive the ore, limestone flux, and coke, with an opening at the bottom for removing the slag and another for tapping out the iron. A blast of hot air introduced near the bottom of the furnace causes the coke to burn, reducing the iron ore to iron and slag. Molten iron from the furnace is drawn out at the bottom into sand beds in small pockets where the iron cools in the form of pigs, or it may run into ladles mounted on trucks which transport it to Bessemer or open hearth furnaces, while the slag

Figure 1—Blast Furnace Plant

is run into pits, granulated with water and hauled away. The hot blast for the furnaces is usually produced by steam engines or centrifugal turbo blowers some of which have a capacity of 45,000 cu. ft. of air per minute. Engines using blast furnace gas are also frequently used.

When the molten steel from the blast furnaces comes to the open hearth plant it is poured into the furnace and mixed with cold scrap iron, ore and flux, thoroughly heated and treated by the burning gas or oil which directly impinges on the top of the molten metal, gradually burning out all the impurities and producing pure steel of the desired grade. Sometimes the open hearth furnace plant is provided with a huge vessel capable of holding many tons of molten iron so that the metal received from the blast furnace may be kept hot until it is ready to be used in the furnaces. When the steel in the furnace is ready, the cast hole in the bottom is opened and the steel drawn out into a big ladle which may hold as much as fifty or sixty tons of steel. An overhead crane lifts the ladle and carries it along the top of the ingot moulds resting on small cars. The operator pulls a lever on the ladle which opens a valve in the bottom of the ladle and allows the steel to run out into the moulds. These stand until they become cool and solid enough to permit the moulds being removed by raising them with a machine called a stripper. The steel ingots which weigh from one to five tons are now ready for the rolling mills.

The Bessemer converters treat the steel quite differently and a different kind of steel is produced.

In some plants the molten iron from the blast furnaces is carried in ladles to a mixing and storage vessel where it is stored until it is required. Other plants use cold pig iron that must be melted in cupolas before it can be put into the converters. A Bessemer converter is a steel shell lined with clay having a perforated bottom through which a blast of air is blown. This perforated bottom receives the air from a pipe connected with one of the trunnions, forming a flexible joint so that air may be introduced with the vessel in any position. The vessel is tipped on its side, about ten tons of molten iron poured in and the blast started as the vessel is turned upright. The blast of air passing through the iron burns out all the impurities and when the metal is poured into a ladle, carbon and other ingredients are added to give the steel the right characteristics. It is then cast into ingots in a manner similar to that used in the open hearth furnaces.

These ingots, both open hearth and Bessemer steel, must be heated to an even temperature throughout before they can be rolled, this heating taking place in closed pits called soaking pits where producer gas is usually burned. The ingots are removed from these pits and placed on buggies which carry them to the blooming mills. A blooming mill consists essentially of two heavy cast steel rolls driven by a steam engine or electric motor which sometimes develops from 20,000 to 35,000 h.p. The metal is rolled back and forth between these rolls and is squeezed down to the desired dimensions, at the same time being greatly lengthened. These products are called slabs or billets according to the shape when they leave the blooming mill, and are cut to the desired lengths by shears while still hot. These semi-finished pieces after being reheated, are then rerolled in other rolling mills, of which there are many designs, into plates, rails and shapes of all kinds.

The manufacture of iron and steel and the process of rolling it into the final shapes requires the use of so many different kinds of machinery and involves so many different conditions of operation, which have a great influence on the kind of lubricants selected and the method of application, that it is very difficult to state lubricating conditions in a general way. However, the chief points to be lubricated in a plant producing finished steel from the ore may be generally divided into the following classifications—general mill bearings, electric motor bearings, steam engine bearings, steam engine cylinders, pinions and gears, wire ropes. In selecting lubricants for any particular machine coming under one of these general classifications consideration should be given to the extent to which it is exposed to ore dust, steel dust, heat, gases, water, cold weather and numerous other influences. To help us discuss what kind of lubricants will best meet these conditions a description will be given of one of the very large steel plants lubricated throughout with Texaco Products. Realizing the important part that lubrication plays in the efficient operation of its plant, this concern has given us permission to publish this information in the hope that it may help other steel men to improve the operation of their plants, increase their production and their service to Uncle Sam.

This steel mill secures its iron for its open hearth furnaces and Bessemer converters from a blast furnace plant of five furnaces. When the ore is received, the cars are run upon a trestle and dumped

by gravity, the ore being distributed over the ore farm and delivered to the bins by three ore bridges—two Brownhoist and one Wellman-Seaver-Morgan. The first furnace was built just after the close of the Civil War and although repaired and relined many times it is still capable of turning out its share of iron. Perhaps a good deal of the credit for its performance is due to the devotion of its men, one of whom, Joseph Honey, has looked after the mechanical repairs for forty-five years. We doubt if there is another millwright in the country with a service record like this, and although it has been said that blast furnace work cuts off many years from a man's term of life, he is strong and better able to do a hard day's work than many a younger man.

When this furnace was built there were no automatically filled tops or skip hoists so a platform elevator was provided, the hoist drum being driven by a small vertical engine and the ore, limestone and coke being hoisted up to the charging floor and dumped into the top of the furnace by hand. The necessary blast is supplied by two vertical blowing engines of comparatively recent origin, installed in 1896 by the Edward P. Allis Company of Milwaukee, and a third engine built by Weimer Machine Works added to the plant in 1902 for a spare. These engines are operating on 125 lbs. steam pressure and exhausting to the atmosphere. At the time they were built continuous circulating oiling systems were very rarely used, so they were equipped with drip cups filled by hand, and as no provision was made for collecting the used oil and saving it, a fairly heavy bodied oil of high lubricating value was selected. This gives the engineer the chance to use small quantities and keep the engine room clean.

The second furnace, built a few years later is quite similar in construction to the first one although having a few improvements. The other three furnaces have modern automatic tops with inclined skip hoists, one of them being steam driven and the other two electric motor driven.

Furnaces Nos. 2, 3 and 4 receive the blast from nine vertical cross compound Allis-Chalmers and one William Tod blowing engines. These engines are all located in the same engine room, 300′ x 85′, and are equipped with a 10,000 gallon continuous circulating oiling system. When this system was designed it was the intention to place it in the cellar, but quicksand was encountered, so only the catch tank was placed below the engine floor. From this tank the oil is pumped to the three 3,000 gallon rest tanks, where the oil is brought to a complete rest, allowing the water received from the piston rod stuffing boxes, and the sediment and dust washed out of the bearings and off the engine frames, to settle out by gravity. From these tanks the oil drains to the filters which remove the floating foreign matter, the clean oil being pumped up to the overhead tanks for re-use. Vertical engines such as these, 67 feet high, lose more oil through evaporation than those of the horizontal type because the oil is exposed to air for a longer time as it flows down over the base. Any breeze in the room tends to blow the oil away, and losses also occur by splashing from the fly wheel and leakage from the fly wheel pit. In view of these conditions the addition of only twenty-two gallons of Texaco Engine Oil per twenty-four hours constitutes quite a record for so

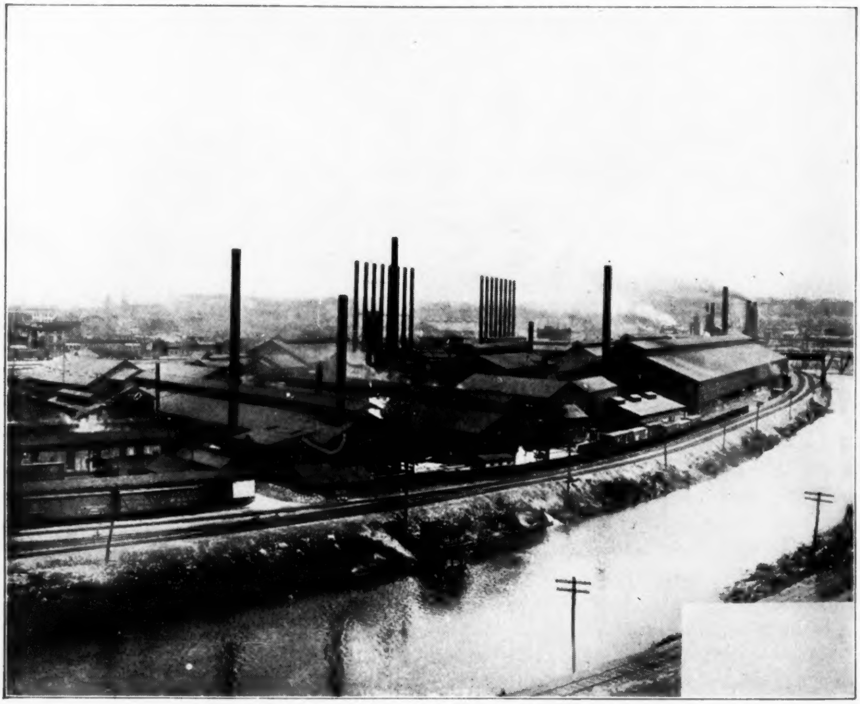

Figure 2—Another of the Main Plants

many engines of this size and type. The air tubs are lubricated with less than one-half gallon of Texaco Air Tub Oil per engine, and the steam cylinders with $2\frac{1}{4}$ gallons of Texaco Cylinder Oil per engine per twenty-four hours, supplied by Richardson mechanical lubricators.

The fifth furnace was built in 1916 and is equipped with a modern automatically filled furnace top and skip hoist. The blast is supplied by General Electric steam turbo-blowers, one being in continuous operation with one as a spare. These turbines operate on 175 pounds steam pressure with 100° F. superheat at 3000 to 3600 r. p. m. developing a maximum horsepower of 6700. A circulating oiling system lubricates the bearings which are 10 inches in diameter with Texaco Turbine Oil at a pressure of 35 pounds.

Steam for all of these engines and the units in the electric power house described later is generated in three sets of boilers, burning blast furnace gas together with a little coal. The boilers supplying steam to the engines for No. 1 furnace are old and carry only 125 pounds pressure while the No. 2 boiler house develops steam at 150 pounds. All of this steam is saturated and although the steam lines are not long, the steam is quite wet by the time it reaches the cylinders. Until recently the boiler water has been very bad, as it is taken directly from a small stream, badly contaminated from other steel plants further up the river, but a new water softening plant has just been built to furnish the boilers with better water. Steam for the turbo-blowers is generated in a new boiler plant at 175 pounds

Figure 3—Coke Works

pressure and 100° F. superheat. Steam conditions may be considered as about average for blast furnace plants. Texaco Cylinder Oil compounded to handle this class of work is used in all steam cylinders of blowing engines and auxiliaries such as hydraulic pumps, vacuum pumps, as well as air compressors, mud guns, hoisting engines and boiler-feed pumps.

Texaco Engine Oil is used on all bearings of engines and auxiliaries, vacuum pumps, air compressors and electric motors, where a high-grade oil is required. The rougher sort of bearings such as those on the ore bridges, slag cranes, cast house cranes, larry cars, hot metal ladles and the bearings of the hoist and furnace tops exposed to ore dust, slag, gases and all sorts of weather are lubricated with Texaco Black Oil.

In this plant part of the molten iron from the furnaces is delivered to the open hearth plant, consisting of fourteen modern 65-ton furnaces, equipped with water cooled doors, boshes, etc., and electrically operated equipment. In connection with these furnaces there are also a 40″ blooming mill, 18″ – 21″ billet mills, 90″ plate mill, and 14″ – 16″ continuous mills for producing finished and semi-finished steel.

There is not very much machinery in an open hearth furnace plant to lubricate except the chargers and cranes for handling the raw material and the molten steel. Raw material such as scrap iron and ore is charged into the furnaces by three electric Wellman-Seaver-Morgan chargers, while the molten iron is poured into the furnaces from the ladles by huge Alliance electric

traveling cranes. There are also three more ladle cranes for handling the ladles of finished steel. The cables, gears, hoists and trolleys of these cranes are directly exposed to the extreme heat of the white hot metal and the hot gases, arising from the boiling steel during the tapping of the furnace, attack the lubricants causing them to dry up and quickly disappear unless they have been especially manufactured to meet these conditions. This applies particularly to the cables holding the hooks raising the ladles and here Texaco Crater Compound is used because it has the necessary adhesiveness even when exposed to high temperatures and is not affected by gases.

When the metal in the ingot moulds has become solid the moulds are stripped from the ingots by a Morgan stripper crane and the ingots are then placed in the soaking pits where they are heated to an even temperature by producer gas from a battery of Hughes Gas Producers. Morgan charging cranes handle the hot ingots from the pits to the ingot buggy which carries them to the blooming mill.

From the time the iron enters the open hearth furnaces up to the time it is delivered to the rolling mills the only equipment requiring lubrication is electrically driven, and the influences which affect the lubricants are extreme heat, dirt, steel dust and gases. Texaco Engine Oil is used in the bearings of all electric motors, Texaco Black Oil and Texaco Cup Grease for bearings of cranes, and Texaco Crater Compound on all gears and cables.

Rolling mill conditions are quite different as will be found from the description of the blooming mill. This is a 40″ reversing mill built by the United Engineering & Foundry Co., and is driven by a 44″ x 60″ twin tandem compound William Tod reversing engine. Probably the most important parts of the blooming mill requiring efficient lubricants are the pinions and gears, roll necks and screw-down which, in this case, is electrically operated. The pinions are enclosed in an oil-tight casing forming a bath and are lubricated with Texaco Crater Compound which forms on the teeth a heavy film that is thick enough to withstand the terrific hammering and pounding when the mill is reversed. The necks of the pinions are lubricated with Texaco Black Oil.

Roll necks are lubricated with roll neck grease and flooded with water, and this water splashing on the beveled gears driving the table rollers nearest the rolls makes it very difficult to apply the gear lubricant, and together with the flying scale and the heat from the hot metal, renders the use of high grade lubricants absolutely necessary. Texaco Crater Compound is applied by pouring it onto the teeth at the point of mesh when the gears are running inward, the number of applications depending upon the amount of steel rolled through the mill. The screw-down, which consists of two long screws for raising and lowering the rolls, is lubricated with Texaco Cylinder Oil, as a smooth lubricant capable of withstanding great pressures is required.

The engine driving this mill takes steam at 150 pounds pressure, with 70° F. superheat developed at the boilers, and as the steam line between the boiler house and engine is very short a considerable percentage of this superheat still exists when the steam reaches the engine. Two 6-feed Richardson-Phoenix mechanical lubricators with two feeds into the steam line for atomization

of the oil and the balance direct to valves and cylinders, feed from twelve to fifteen gallons of Texaco Cylinder Oil per twenty-four hours, the amount depending upon the operation of the engine. A continuous circulating oiling system supplies the bearings with a flood of oil which is collected, the entrained water and sediment allowed to separate, and the oil filtered and re-used. As the engine is located in a separate room from the mill it is cleaner and the oil does not pick up as much dirt as some of the other engines which are exposed to the ordinary mill operating conditions. On this engine there are no guards to prevent oil from flying out of the crosshead guide barrels or from the crank pits, and as the engine operates at a high speed, starting, stopping and reversing in an incredibly short space of time, great quantities of oil are splashed and thrown from the engine through these unguarded spaces out onto the engine room floor. Large quantities of oil are also splashed on the cylinder heads where it is burned, and these losses together with natural vaporization and leakage require careful attention on the part of the engineer to keep the consumption at a minimum.

As this mill rolls slabs and blooms, two sets of gear driven run out tables are provided, one equipped with a steam slab shear and the other with a hydraulic shear. The blooms are taken up a transfer table to the 18″–21″ Morgan Construction Company continuous billet mills. These mills are driven through individual pinions by beveled gears on a line shaft directly connected to a 48″ x 84″ x 60″ cross compound Corliss engine built by the Mesta Machine Company. These gears which range from 3 ft. to 11 ft. in diameter are machine cut with teeth of 5″ pitch and 12½″ face. The speeds range from 18½ r.p.m. to 105⅔ r.p.m. Such gears require a very heavy bodied lubricant to maintain a film on the teeth and on this account Texaco Crater Compound was selected. The same lubricant is also used in the herringbone pinions which are contained in oiltight cases affording continuous lubrication.

In addition to these mills there are also 14″–16″ mills which are similar in design, for rolling skelp and shapes. These mills are driven in exactly the same way by a 36″x 60″ cross compound Corliss valve, Cooper Engine. Both of these engines have continuous circulating oiling systems, the 18″–21″ mill engine using 70 gallons per week and the 14″–16″ mill engine using 15 gallons per week of engine oil. The latter mill is located some distance from the boiler house and the steam is received in a fairly wet condition which is taken care of by the compound in Texaco Cylinder Oil.

The 90″ three-high plate mill presents another set of conditions because of the quantities of salt which are thrown on the plates during the process of rolling and the fact that the red hot plates pass directly over and rest upon the bearings and gears of the table rollers. This salt, together with the water from the roll necks, flying scale and dust, driven with considerable force when the hot gas explodes, tends to destroy any lubricant used on the roll necks, table roller bearings and gears. Because of its resistance to heat, salt water and all acids and alkalies, Texaco Crater Compound, when properly applied in sufficient quantities, prevents these gears from becoming dry and rusty. The mill is driven by a 34″ x 60″ x 60″ tandem compound William Tod engine through

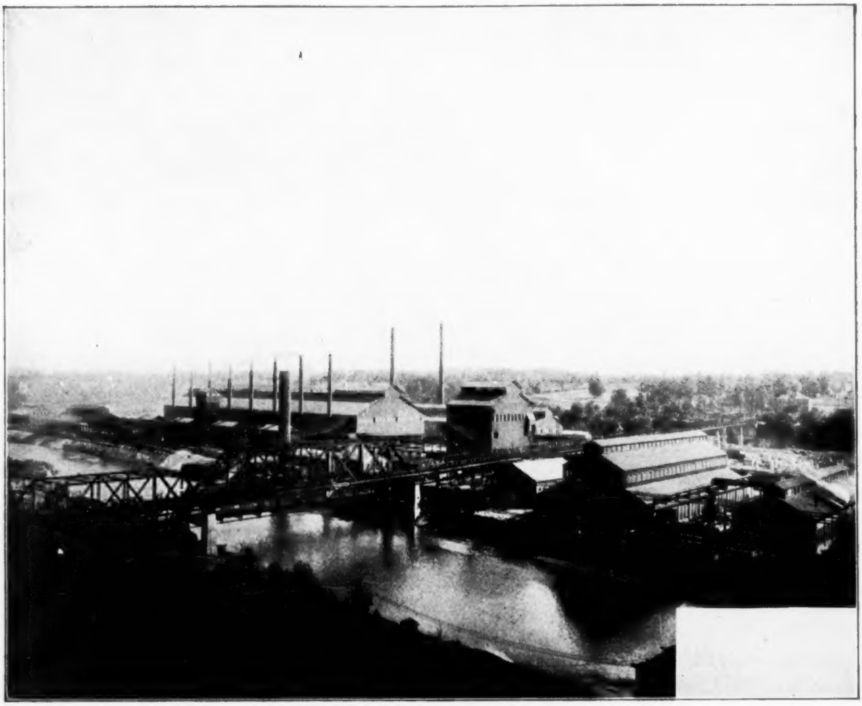

Figure 4—Open Hearth Plant

a three-high herringbone pinion set. As the pinions are in an open housing exposed to steel dust arising from the rolling of the plates, and as considerable oil works out onto the gears from the pinion necks, a high grade lubricant is required. From the mill the plates are carried by rollers to a cooling bed and thence to the shears, of which there are two, gear driven, built by the United Engineering & Foundry Company. Crater Compound is used on the gears with Texaco Engine Oil on the bearings.

Throughout this department all equipment is kept in the best of condition, being modern and fitted with up-to-date devices for efficient operation. Engines are located in separate rooms and are equipped with mechanical force feed lubricators as well as circulating oiling systems with filters and settling tanks. Texaco Engine Oil is used on all engine and electric motor bearings, Texaco Black Oil on all mill and table rolling bearings with Texaco Crater Compound on all gears and cables, and Texaco Cylinder Oil in the steam cylinders.

Bessemer Steel is made in two 10-ton Bessemer converters, which receive iron from the mixer and from the cupolas. These converters are tipped for pouring the finished steel and for receiving a new charge of iron by two hydraulic plungers, operating racks on either side of a pinion on one of the trunnions. These gears of course get very hot from the conducted heat of the molten steel and a very adhesive heat-resisting lubricant is required for both gears and plungers. The blast for blowing the iron into steel

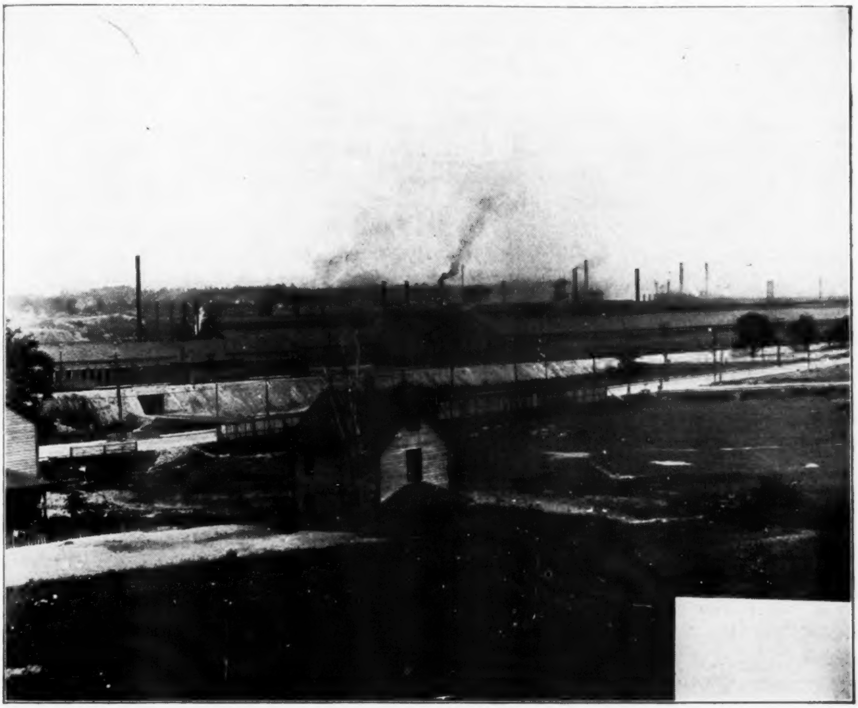

Figure 5—Tube Mill

is supplied from two Allis-Chalmers blowing engines, one vertical and one horizontal. Both engines are equipped with circulating oiling systems and mechanical lubricators and each uses three gallons of cylinder oil per twelve hours and only thirty-five gallons of engine oil per month.

From the vessels the steel is poured into a ladle carried by a steel crane swinging about a vertical axis, the gears operating this crane being subjected to heat, slag and steel dust. The operation of removing the moulds and heating the ingots ready for the blowing mill is very similar to that explained in connection with the open hearth plant—two 100-ton hydraulic Aitkins Strippers, and two Case and one Alliance Electric chargers constitute the necessary equipment.

The blooming mill is a 40″ mill built by the United Engineering & Foundry Company, driven through spur tooth, machine cut pinions from a William Tod twin 54″x66″ reversing engine. These pinions are covered with shields which are not oil tight and as there is no bottom to the gear case the lubricant must stick to the pinions from one oiling to the next and maintain a film in spite of the hammering and pounding which the teeth receive when the mill reverses. The pinion necks are lubricated with oil, a portion of which works out on the gear teeth and tends to wash the gear lubricant off, so that it must have qualities which resist this action. The rolls are raised and lowered by screws similar to those previously mentioned.

All table rollers are driven through

bevel gears, unprotected from the heat of the metal and flying scale save by a metal side plate and cover plate. In addition to the heat from the metal, the gear sets nearest the rolls receive a small amount of water splashing from the necks and also receive quite a bit of oil which works out from the table roller and jack shaft bearings. This has a very bad influence on the gear lubricant and requires the use of an especially adhesive and heat-resisting material.

The engine driving this mill operates non-condensing using steam at about 145 to 150 pounds pressure, containing considerable moisture. Reversing blooming mill engines are always hard to lubricate because the sudden drafts of steam and the wide variations in loads produce large amounts of water of condensation tending to wash the oil off the cylinder walls. The irregular action of the engine causes an irregular feed of oil which does not always vary in proportion to the amount of steam used, so that an excessive quantity may be fed at one time and not enough at another. Ten gallons of cylinder oil are used in this engine per twenty-four hours.

As the engine is located in the same building with the mill it is naturally exposed to all the dirt, steel dust, and scale that always exists in such places, and as a result the engine oil is severely taxed. A circulating oiling system keeps the oil in good shape with the addition of only eight barrels of oil per month. This is very economical if due consideration is given to the conditions under which this unit operates, and to the fact that eccentrics, valve gear, crossheads and crank pins are exposed, and the high speed atomizes and throws the oil beyond the possibility of its draining back to the catch tank.

As the billets and slabs are delivered from the mill tables they are carried down the building by gear driven table rollers, the slabs being diverted to a Mackintosh-Hemphill steam slab shear. The billets are cropped by a United Engineering & Foundry Company hydraulic shear, the butt ends being carried out on a conveyor and dumped into cars while the billets are conveyed on table rollers to the 26″ mill. This mill, also built by the United Engineering & Foundry Company, consists of three stands of rolls, two of them rolling one way and the other set rolling in the opposite direction. The billet is directed by guides through the proper passes in the first and third stands, and is then raised up and dropped into another set of guides which direct it back through the passes of the second set. These guides of course, come in direct contact with the hot metal and are painted with Texaco Crater Compound, which sticks in spite of the heat and permits the metal to slide easily. This is an unusual construction and the service is extremely severe. The rolls are driven through herringbone pinions from a set of heavy gears by a William Tod tandem compound 44″ x 80″ x 60″ engine. The pinions are so constructed that it is necessary to lubricate the bearings with grease and to keep a large quantity of water constantly flowing on them to keep them cool. The water splashes onto the pinions and, unless the lubricant is especially adhesive and adapted to working with water, it will wash off and cause the gears to cut. The cases are not tight and it is not possible to provide a bath of oil, so it was necessary to select a material that will withstand the water and maintain a film on the teeth thick enough to afford efficient

lubrication. Texaco Crater Compound was selected.

From the 26″ mill the steel goes out onto a transfer table which transfers it to another roll table, conveying it back to the first stand of the 28″ three-high mill. There are two of these sets of rolls both driven from the same set of pinions which are of the herringbone type, machine cut, and are subjected to the same kind of service as those in the 16″ mill. After the steel passes through both of these sets of three-high rolls it is finished in a two-high roll stand, separately driven by herringbone pinions from driving gears connected to the same engine which drives the three-high rolls. This is a 54″ x 60″ Filer-Stowell engine equipped with force feed lubricators and a circulating oiling system using 3½ gallons of cylinder oil per day and 200 gallons of engine oil per month. As this engine is located in a separate building from the mill, being connected to the driving gears through a long spindle, it does not receive as much dirt as the others and, consequently, the filters are not so severely taxed.

The 18″ continuous mill consists of four stands of rolls built by the Morgan Construction Company, driven by separate sets of pinions from driving gears connected to the shaft of the engine, a cross compound 44″ x 60″ Filer-Stowell engine. These pinions and gears like those in the 26″ and 28″ mills, are lubricated with Texaco Special Crater Compound because of the severe water conditions.

This comprises the equipment in the mills for rolling Bessemer slabs and billets. The semi-finished steel is then delivered to the various finishing mills where it is heated and re-rolled to the desired size and shape.

This company has a very extensive finishing plant capable of turning out a great variety of rounds, squares and flats including small structural shapes. There are nine mills including a 20″ bar mill, a 12″ bar mill, two 10″, two 8″ and one 7″ merchant mills, a 10″ and a 20″ skelp mill. There are also several spike machines and washer machines and a number of tube mills.

The 20″ bar mill was originally a hand mill built forty or fifty years ago and has been repaired and rebuilt so many times that it is now a modern mill from a production standpoint, and nothing remains of the original mill except the name. There are three sets of three-high rolls driven through one set of pinions by a belt from a 40″ x 48″ Bass Corliss Valve engine.

The 12″ mill is also an old hand mill of five stands directly connected through one set of pinions to a William Tod 24″ x 34″ engine.

The five merchant mills, although differing in the details of their construction, are generally similar, some of them having a number of rolls driven through the same set of pinions, while other rolls are individually driven by separate pinions from the engine. With the exception of the pinions driving the roughing rolls of the 7″ and 8″ mills, all of the pinions throughout these mills are flooded with large quantities of water, as the necks are lubricated with roll neck grease and kept cool with water. These pinions are of the herringbone type and, as in most cases several sets of rolls are dependent upon one set of pinions, it is very important that they be properly lubricated. If there is any sticking, catching or chattering in the pinions, or if the points ride, by the time the motion reaches the rolls on the end, it has been greatly exaggerated by the lost motion of the different sets so that serious trouble many times

will be caused in the finishing of the material. With separately driven final finishing rolls, of course, this danger is greatly reduced, although it should always be considered when selecting a pinion lubricant. For this character of work the lubricant must be heavy in body and possess great powers of adhesion in the presence of water to meet such conditions. Texaco Crater Compound was selected.

Conditions in the two skelp mills are a little different. The 10″ is a Morgan continuous mill having five roughing stands, two sets of roughing edging rolls, one set of intermediate edging rolls and four finishing rolls. All of the roughing rolls are driven through individual pinions connected to a gear drive from a cross compound 24″ x 48″ x 45″ Southwark engine. The intermediate edging rolls are direct connected to a 20″ x 30″ Southwark engine and the finishing rolls are belt driven through individual pinions from a 28″ x 48″ x 48″ cross compound Southwark engine. Here the pinion necks are lubricated with a small amount of roll neck grease but receive the greater part of their lubrication from the gear lubricant which works its way out to the necks from the splashing in the enclosed case.

The 20″ skelp mill is a three-high mill of two stands driven through one set of pinions by a 40″ x 48″ Southwark Corliss engine. One finishing stand is rope driven from the same engine.

In all of these mills there are a number of shears, hydraulic, steam flying, and gear driven for trimming and cutting stock both hot and cold, as well as the usual number of transfer tables, cooling beds, electric cranes, scales, etc.

Except for the skelp mill engines, which are equipped with circulating oiling systems, all engines are oiled by drip cups filled by hand. Economical consumption requires the use of fairly heavy bodied oil, as bearings are not tight and receive quantities of steel dust from the mills. Pulley and rope drive shaft bearings are fitted with reservoirs holding about two gallons placed over the oil hole in the top of the bearing and the oil allowed to flow in a steady stream is caught in buckets and poured back into the reservoir to be used over again.

Steam cylinder lubrication presents rather difficult problems as many of the lines are long and a considerable amount of moisture collects by the time the steam reaches the engine. Steam is generated at 150 pounds pressure in Stirling boilers equipped with Roney and Taylor mechanical stokers.

The tube mills, for the manufacture of practically all sizes of black and galvanized standard pipe and casings, are very modern in their design and are electrically operated throughout. Welding rolls are driven through machine cut herringbone pinions enclosed in a most efficient oiltight casing; Texaco Crater Compound is used in these casings with no visible leakage or evaporation. All gears and cables of welding rolls, skelp chargers, cross rolls, straightening machines, etc., are lubricated with the same material.

Outside of the actual lubrication of the mechanical and electrical equipment in the tube mills very considerable quantities of oil are used for lubricating the cutting tools of threading machines and socket tapping machines. For threading the smaller sizes of pipe a soluble oil has been found to give the most satisfactory results, while for the larger sizes a compounded cutting oil works better than the soluble oil. Neither of these lubri-

cants can be used for tapping the sockets and the only thing that seems to work here is straight lard oil. The cutting oils are supplied to the individual machines from a central storage and circulating system which collects the used oil as it drains from the machine, separates the chips and particles of steel by means of a centrifugal filter and returns it to the storage tank as good as new for further use. A circulating system of this kind saves thousands of dollars in the cost of oil in one year.

After considering this detailed description of an actual plant we may now sum up generally the types of lubricants which may be used and their characteristics.

General Mill Bearings—This general classification includes bearings on line-shafts, counter-shafts, table rollers, rollers, gears, pinions, shears, electric cranes, hoists, ore bridges, etc. These bearings are, in general, cast iron, steel or babbitted, are not tightly fitted and soon become worn out with the cutting action of the dirt and steel dust. While some of them are equipped with ring oilers, many of them have drip cups or pockets for waste. A good heavy bodied black oil will lubricate them satisfactorily.

Electric Motor Bearings.—Bearings of electric motors used in steel mills are usually, but not always, ring oiled and of a higher class of workmanship than the bearings mentioned just above. The shafts run at higher speeds, the bearings fit closer, and a good medium bodied engine or motor oil should be used.

Steam Engine Bearings.—The oil for this service depends largely on whether a circulating system is provided or whether the bearings are lubricated by drip cups or ring oilers. Generally speaking, engines having circulating systems may use a lighter bodied oil than those with drip cups, as larger quantities can be fed to the bearings and oil collected and saved by the catch tank. Such systems should be large enough and so arranged as to provide ample capacity for allowing the dirt and entrained water to settle out, leaving the oil clean for further use.

Steam Cylinders.—In a plant of this size where there are numerous boiler houses developing steam at different pressures ranging in this particular instance, from 125 lbs. saturated to 175 lbs. with 100° F. superheat, and with cylinders using steam at pressures and temperatures from 175 pounds all the way down to pressures below atmosphere in the low pressure cylinders of compound cylinders, with a moisture content varying from zero up to three or four per cent., boiler water containing quantities of alkali and other substances injurious to cylinder oils, it is quite a difficult matter to select a proper steam cylinder oil. It is advisable, whereever possible, to pick out one oil which will best meet all of these conditions, as the use of different grades of cylinder oils in one plant always leads to confusion, particularly when the lubrication is handled by the type of oilers employed in steel mill work. While the oil which might work most economically in the cylinder taking superheat steam at 175 pounds pressure would also lubricate the low pressure cylinder of a compound engine, a greater quantity might be required than if an oil were selected to exactly meet the conditions within the low pressure cylinder. The difference in economy in a plant of this character is more than offset by the advantages of using only one grade of cylinder oil.

Pinions and Gears.—In a steel mill the lubricant on the gear teeth

always collects steel dust and dirt which rapidly cut out the teeth unless the lubricant is heavy enough in body and possesses certain characteristics which enable it to lubricate such particles, reducing the abrasive action. The high temperatures to which the gear teeth are exposed, the splashing of water, the action of gases and fumes must all be considered when picking out a gear lubricant.

Texaco Crater Compound has been manufactured with all of these requirements in view and was selected by this steel company for such lubrication throughout their plant.

While the equipment mentioned in the foregoing pages may be considered as strictly steel plant machinery, if electric power is used in the operation of the many electric motors, cranes, etc., it must either be purchased or developed by prime movers very similar in design and operation to those built for commercial lighting and power purposes. At this plant electric power is developed in a number of separate plants located at points advantageous for distribution to the various mills; direct connected steam engines of a number of makes drive Westinghouse, Allis-Chalmers and General Electric generators producing both D. C. and A. C. power. There are also a number of steam turbines, among them being one 3500 k. w. and two 2500 k. w. General Electric units and one 750 k. w. low pressure steam turbo-generator. Texaco Steam Turbine Oils are used throughout.

While the selection of the right lubricant is most important, the equipment used for its application, the care and attention given to the operation of this equipment, and the means provided for handling and storing the lubricants from the time they are received to the moment of use, have a great bearing on the economy which may be secured.

In the first place, the number of different lubricants used is reduced to a minimum, making it possible to purchase large quantities of a few lubricants in bulk and to secure a lower price than if small quantities of many kinds of lubricants were used. At this plant oil is purchased in tank cars and delivered to a central storage house from which it is distributed as needed to the various departments and machines. A regular allowance has been adopted for each machine and daily withdrawals from the oil house are carefully checked against these allowances. If an excess is used on any day, it is promptly investigated and the cause determined. Through such a system, efficiently and tactfully administered, surprisingly large economies have been effected. Costs per ton of steel output are calculated for each department and when any general increase is shown a prompt investigation is made.

Engine oiling systems are regularly inspected, water separated by the rest tanks drained off and filter bags cleaned and leaks stopped. The amount of oil in the system is checked up and regular additions made to maintain the proper capacity. Such attention keeps the engine oil in good condition and gives the systems a chance to do their work efficiently.

In connection with the attention given to lubricants and lubrication by the plant operators, the lubrication engineers of The Texas Company regularly inspect all the equipment to see that the right lubricants are being used, that they are giving proper service, that consumption is in line, and assist in working out lubricating problems on new equipment and when new conditions develop on old machinery.